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NOMENCLATURE OF COPPER ALLOYS - BRASS AND BRONZE

The National Bureau of Standards receives many requests concerning the proper use of the names "brass" and "bronze", as well as for advice concerning suitable alloys which are adequate to meet certain service requirements. This Letter Circular has been prepared as an aid in replying to such inquiries.

I. Introduction

Brass and bronze castings have been traced back thousands of years, and the available histories (of these parts) clearly indicate that bronze, the alloy of copper and tin, was the predecessor of brass, the alloy of copper and zinc. Even today, the definitions of these terms make clear their differences with respect to the alloying addition.

Well after the early use of copper castings, it was accidentally discovered that a "mixture" of ores resulted in much stronger and more corrosion resistant materials. These "mixtures" came into general use, and the alloys became symbolic of our Bronze Age. Much later, zinc was also used in these alloys; thus the brasses. Developments through the centuries bring us to where it is now recognized that, weight-for-weight, tin is more effective than zinc in enhancing the mechanical properties of copper. Today, either or both of these metals, as well as many others, are added to copper in order to achieve special properties. Thus, it becomes extremely difficult to classify currently used alloys strictly by definition; for, while the term "brass" has had no serious degree of misuse, the term "bronze" is currently used "in the trade" for a wide variety of alloys, some of which contain little or no tin. In fact, the situation is so complex that, to clarify, the original copper-tin alloy is now designated as "tin-bronze."

Because of this complexity, it is recommended that the reader, when encountering any of the currently used descriptive or trade-names indicated as being "brass" or "bronze", refer to standard metallurgical references such as the National Metals Handbook<sup>(1)</sup>, Classifications and Materials Specifications established by the American Society for Testing Materials<sup>(2)</sup>, or the American Standards Association<sup>(3)</sup>, data from the Copper and Brass Research Association<sup>(4)</sup>, or to the strictly technical literature usually provided gratis by the producers of these alloys.

## II. Classification of Alloys

In the interests of classifying the many copper-base alloys in current use, A. S. T. M. has established a Classification of Cast Copper-Base Alloys (B 119-45), and has developed many specifications for particular classes of alloys, for general purpose as well as specific applications, including both cast and wrought materials.

For specific information, the reader should refer to such specifications. However, as an aid to the present discussion, Table I presents a much abbreviated version of such a classification for casting alloys, while Table II denotes the nominal compositions and cites a few applications of some of the alloys characterized by particular names.

In addition to the alloys listed in the two tables, there are a host of alloys offered by the producers under trade names, the compositions of which may or may not be classified or standardized.

From a perusal of Table 2, it is quite evident that industrial terminology has indeed departed materially from strict definitions, particularly with respect to "bronzes". This has been carried to even further extremes in other instances concerning decorative finishes wherein "bronzed" covers a multitude of applications. Also, the term "bronzing paints" has been abused with respect to metallic particle paints, whether of copper, copper-zinc, or aluminum.

## III. "Standard" Alloys

1. There is a widespread misconception that the names of many of these alloys imply that they are the standard alloys for such application. This is particularly pertinent with respect to "Government Bronze", "Naval Brass (or Bronze)", "Statuary Bronze", and others. Most of these names derive from some particular application in the past, and they must not be considered as the typical, specified, or standard alloy for the purpose supposedly indicated. Actually, most of the copper-base alloys are classified and standardized on the basis of chemical composition, as indicated in Table 1.

2. For any particular application, the potential user should select an alloy which has physical, mechanical, chemical, or corrosion properties which fulfill his service requirements; then specify this alloy in terms of ASA, ASTM, SAE<sup>(5)</sup>, AMS<sup>(6)</sup>, Federal, or the appropriate specification of the Department of the Army, or Navy, or Air.

- Ref. 1. National Metals Handbook, American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio
2. ASTM Standards, Part 2, American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania
3. American Standards Association, 70 East Forty-fifth Street, New York 17, New York
4. Copper and Brass Research Association, 420 Lexington Avenue, New York 17, New York
5. Society of Automotive Engineers
6. Aeronautical Materials Specifications

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Chemical Metallurgy Section

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Table 1. Classified Casting Alloys

Alloy	Weight Percent					ASTM Spec.
	Cu	Sn	Pb	Zn	Other	
Leaded Red Brass	82-86	3-6	4-7	4-8	-	B 62, 145
Leaded Semi-Red Brass	75-82	3	5-8	7-17	-	B 145
Silicon Brass	bal	-	.5-1	12-16	Si 2.5-5	B 198
Yellow Brass	bal	0-6	0-.5	17+	Al, Mn, Ni, Fe, & Si, 0-2	-
Leaded Yellow Brass	60-74	1	3	25-29	-	B 146
High-Strength Yellow Brass (Manganese Bronze)	55-68	0-1.5	0-1.5	bal	Ni 0-.5, Fe .4-4, Al .5-7.5, Mn 0-5	B 147
Leaded High-Strength Yellow Brass (Leaded Manganese Bronze)	56-62	0-1.5	.5-1.5	bal	Fe 0-3, Al 0-1.5, Mn 0-3.5	B 132, 147
Nickel Brass (Nickel Silver) (German Silver)	bal	-	0-.5	10+	Ni 11+	-
Leaded Nickel Brass (Leaded Nickel Silver) (German Silver)	53-58	1-3	8-11	bal	Ni 11-14, Fe 0-1.5, Mn 0-.5	B 149
Aluminum Bronze	81-89	-	-	-	Fe 1-4, Ni 0-4, Al 9-11	B 148
Beryllium Bronze	98	-	-	-	2 Be or Be plus others	-
Manganese Bronze	55-68	0-1.5	0-1.5	bal	Ni 0-.5, Fe 0.4-4, Al 0.5-7.5 Mn 0-5	B 147
Nickel Bronze <sup>†</sup> (Nickel Silver) (German Silver)	bal	10	0.5	less than Sn	Ni 10	-
Leaded Nickel Bronze (Nickel Silver) (German Silver)	63-67	3.5-5.5	1.5	bal	Ni 19.5-27, Fe 0-1.5	B 149
Silicon Bronze	bal	0-1	0.5	5	1-5 Si, Fe 0-2.5 Al 0-1.5 Mn 0-1.5, Mn 0-1	B 198
Tin Bronze	88	8-10	-	2-4	-	B 22, 143
Leaded Tin Bronze	87-88	6-8	1-2	4	-	B 61, 143
High-Leaded Tin Bronze	70-85	5-10	7-25	0-3	Ni 0.50- 0.75 max	B 22, 66, 67, 144



Table II. Some Common Name Alloys

Brasses	Approximate Weight Percent					Some Typical Uses
	Cu	Sn	Pb	Zn	Other	
Cartridge Brass*	70	-	-	30		Cartridge cases, drawn shells, bead, chain, fasteners, hardware.
Clock Brass (Engravers) (High-Leaded Brass*)	64	-	2	34		Clock and watch backs, channel plate, engravings, gears, nuts.
Commercial Brass (Commercial Bronze*)	90	-	-	10		Forgings, grills, screen cloth, screws, vases, hardware, shapes.
Composition Brass* (Ounce Metal*) (Leaded Red Brass*)	85	5	5	5		Intricate castings, pressure-tight castings, valve bodies, pipe fittings, condenser heads.
Forging Brass* (High-Leaded Brass*)	60	-	2	38		Forgings, tire valve stems.
Fourdrinier Brass	83	-	-	17		Fourdrinier cloth.
High Brass (Yellow Brass, 65%*)	65	-	-	35		Pins, rivets, screws, chain.
Low Brass*	80	-	-	20		Bellows, trim, ornamental, clock dials, tanks.
Matrix Brass (Medium-Leaded Brass*) (Butt or Spinning Brass)	65	-	1	34		Screw machine products, spinning or swaging, dials, nuts.
Naval Brass*	60	1	-	39		Condenser plates, forgings, propeller shafts, welding rod.
Nickel Brass (Nickel Silver*)	-	-	-	-		Base for silver plated ware, costume jewelry, hollow ware.
Red Brass*	85	-	-	15		Trim, bellows, flexihose, tanks, drawing & forming.
Rule Brass (Extra High-Leaded Brass*)	62.5	-	2.5	35		Sheet products, punched parts.
Spinning Brass (Yellow Brass*) (Butt or Matrix Brass)	68	-	-	32		Couplings, screws and rivets, engravings.
Spring Brass	72-75	-	-	25-28		Springs, stamping.
Trumpet Brass	81	1	-	18		Musical instruments.
Tube Brass (Low-Leaded Brass*)	66	-	.5	33.5		Drain tubes, lens barrels, plumbing goods, flashlight shells.
Yellow Brass* (High Brass)	-	-	-	-		Plate, sheet, strip, rolled bar, and wire.

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Table II. Some Common Name Alloys - Continued

Bronzes	Approximate Weight Percent				Other	Some Typical Uses
	Cu	Sn	Pb	Zn		
Architectural Bronze*	57	-	3	40		Architectural shapes, butts, hinges, etc.
Bearing Bronze	80	10	10	-		Journal bearings.
(High-Leaded Tin Bronze*)						
Commercial Bronze*, Leaded	89	-	2	9		Simple forgings, hardware, screw-machine products.
Conductivity Bronze	98.5-99.5	0-1.5	-	-	Cd 0-1	Line, trolley, and messenger wire, etc. conducting purposes.
Government Bronze						
(Phosphor Bronze 10%*)						
(Tin Bronze*)						
Hardware Bronze*	85	-	2	13		Rod, bar shapes.
Jewelry Bronze*	87.5	-	-	12.5		Chain, costume jewelry, compacts, lipstick containers, slide fasteners
Nickel Bronze						
(Nickel Silver*)						
Olympic Bronze	96	-	-	1	Si 3	Structural shapes, hardware, tanks, boilers, kettles, marine hardware.
(High Silicon Bronze*)						
Phosphor Bronze*	88-95	3-10	-	0-2	P 0.15-0.35	Heavy duty bearings & plates springs, diaphragms.
(Tin Bronze*)						Castings of good mechanical strength
Statuary Bronze	92	6	-	2		One of many compositions used for statues.
(Ornamental Bronze)						
Steam or Valve Bronze	88	6	1-2	3-5		Valves, manifolds, petcocks, pressure-tight covers & heads.
(Commercial G - Navy M)						
(Leaded-Tin-Bronze*)						
"Name" Alloys						
Admiralty Metal*	71	1	-	28		Condenser, distiller, heat exchanger tubes, ferrules, strainers.
Bell Metal	80	20	-	-		Cast bells.
German Silver	-	-	-	-		
(Nickel Silver*)						
Gilding Metal*	95	-	-	5		Rotating bands, drawing, forming, spinning, blasting caps.
Gun Metal	-	-	-	-		See phosphor bronze 10%
(Phosphor Bronze 10%*)						
(Tin Bronze*)						
Muntz Metal*	61	-	-	39		Trim, angles, wire brackets, brazing rod.

Table II. Some Common Name Alloys - Continued

	Approximate Weight Percent				Other	Some Typical Uses
	<u>Cu</u>	<u>Sn</u>	<u>Pb</u>	<u>Zn</u>		
Navy G (Tin Bronze*)	88	8	-	4		
Navy M (Leaded Tin Bronze*)	-	-	-	-		See steam or valve bronze.
Nickel Silver*	43-78	0-5.5	0-11	bal	Ni 9-27	Base for silver plated ware, costume jewelry, hollow-ware, plate, sheet, strip, bar, forgings, shapes.
Ounce Metal* (Leaded Red Brass*)						

\* See ASTM or C & BRA Standards.

